
Appendix I

Material Safety

Data Sheet

Material Safety Data Sheet

Distilled Mustard (HD)

Date: 22 September 1988

Revised: 01 October 2003

In the event of an emergency
Telephone the RDECOM Operations
Center's 24-hour emergency
Number: 410-436-2148

Section I - General Information

Manufacturer's Address:

U.S. Army Research Development Engineering Command (RDECOM)
Edgewood Chemical Biological Center (ECBC)
ATTN: AMSRD-ECB-CB-CR
Aberdeen Proving Ground, MD 21010-5424

Chemical Name: Bis- (2-chloroethyl) sulfide

Trade name and synonyms:

H; HD; HS
Mustard Gas
Sulfur mustard; Sulphur mustard gas
Sulfide, bis (2-chloroethyl)
Bis (beta-chloroethyl) sulfide
1,1'-thiobis(2-chloroethane)
1-chloro-2 (beta-chloroethylthio) ethane
Beta, beta'-dichlorodiethyl sulfide
2,2'-dichlorodiethyl sulfide
Di-2-chloroethyl sulfideBeta, beta'-dichloroethyl sulfide
2,2'-dichloroethyl sulfide
EA 1033
Iprit
Kampstoff "Lost"; Lost
S-Lost; S-yperite; Schewefel-lost
Senfgas
Yellow Cross Liquid
Yperite; Y

Chemical Family: Chlorinated sulfur compound

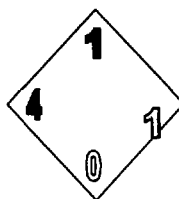
Formula/Chemical Structure:

C₄ H₈ C₁₂ S

ClCH₂CH₂SCH₂CH₂Cl

NFPA 704 Signal:

Health - 4
Flammability - 1
Special - 0



Section II - Ingredients

Ingredients/Name: Sulfur Mustard

Percentage by Weight: 100%

Threshold Limit Value (TLV): 0.003mg/m³

Section III - Physical Data

Boiling Point °F (°C): Calculated 423.5 °F (217.5 °C) (decomposed)

Vapor Pressure (mm Hg): 0.069 @ 20 °C
0.11 @ 25 °C

Vapor Density (Air=1): 5.4

Solubility (g/100g solvent): Negligible in water (0.92 @ 22 °C). Soluble in fats and oils, gasoline, kerosene, acetone, carbon tetrachloride, alcohol, tetrachloroethane, ethylbenzoate, and ether. Miscible with the organophosphorus nerve agents.

Specific Gravity (H₂O=1): 1.27 @ 25 °C

Freezing/Melting Point (°C): 13.88

Liquid Density (g/mL): 1.274 g/mL @ 20 °C
1.268 g/mL @ 25 °C

Volatility (mg/m³): 600 @ 20 °C
910 @ 25 °C

Viscosity (Centipoise): 5.175 @ 20 °C

Molecular Weight (g/mol): 159.08

Appearance and Odor: Normally amber to black colored liquid with garlic or horseradish odor. Water clear if pure. The odor threshold for HD is 0.6 mg/m³ (0.0006 mg/L).

Section IV - Fire and Explosion Data

Flashpoint: 105 °C (Can be ignited by large explosive charges)

Flammability Limits (% by volume): Unknown

Extinguishing Media: Water, fog, and foam, CO₂. Avoid use of extinguishing methods that will cause splashing or spreading of HD.

Special Fire Fighting Procedures: All persons not engaged in extinguishing the fire should be immediately evacuated from the area. Fires involving HD should be contained to prevent contamination to uncontrolled areas. When responding to a fire alarm in buildings or areas containing agents, fire-fighting personnel should wear full firefighter protective clothing (flame resistant) during chemical agent fire-fighting and fire rescue operations. Respiratory protection is required. Positive pressure, full facepiece, NIOSH-approved self-contained breathing apparatus (SCBA) will be worn where there is danger of oxygen deficiency and when directed by the fire chief or chemical accident/incident (CAI) operations officer. In cases where fire fighters are responding to a chemical accident/incident for rescue/reconnaissance purposes they will wear appropriate levels of protective clothing (See Section VIII).

Do not breathe fumes. Skin contact with agent must be avoided at all times. Although the fire may destroy most of the agent, care must still be taken to assure the agent or contaminated liquids do not further contaminate other areas or sewers. Contact with the agent liquid or vapor can be fatal.

Section V - Health Hazard Data

Airborne Exposure Limit (AEL): The AEL for HD is 0.003 mg/m³ as found in "DA Pam 40-173, Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Mustard Agents H, HD, and HT". To date, the Occupational Safety and Health Administration (OSHA) have not promulgated a permissible exposure concentration for HD.

Effects Of Overexposure: HD is a vesicant (causing blisters) and alkylating agent producing cytotoxic action on the hematopoietic (blood-forming) tissues, which are especially sensitive. The rate of detoxification of HD in the body is very slow and repeated exposures produce a cumulative effect. HD is a human carcinogen as cited by the International Agency for Research on Cancer (IARC).

Median doses of HD in man are:

LD50 (skin, liquid) = 100 mg/kg

ICt50 (skin, vapor) = 2000 mg-min/m³ at 70 - 80 °F (humid environment)
= 1000 mg-min/m³ at 90 °F (dry environment)

ICt50 (eyes, vapor) = 200 mg-min/m³

LCt50 (inhalation) = 1500 mg-min/m³

LCt50 (skin, vapor) = 10,000 mg-min/m³

LD50 (oral) = 0.7 mg/kg

Acute Physiological Action of HD is classified as Local and Systemic.

Local Actions: HD affects both the eyes and the skin. Eye absorption results in injuries ranging from mild conjunctivitis to corneal necrosis and opacification (blindness). Infection of the ocular lesions is common. Skin absorption results initially in capillary hyperemia and dermal edema, usually followed by vesication. Being lipid soluble, HD can be absorbed into all organs. Skin penetration is rapid without skin irritation. Swelling (blisters) and reddening (erythema) of the skin occurs after a latency period of 4-24 hours following the exposure, depending on degree of exposure and individual sensitivity. Tender skin, mucous membrane and perspiration-covered skin is more sensitive to the effects of HD. The skin healing process is very slow. The skin effects of mustard agent are dependent on the concentration of the agent and the environmental conditions: a hot, humid atmosphere promotes the most severe skin reaction.

Systemic Actions: Effects can occur after any exposure with much individual variation. Like other alkylating agents, systemic absorption results in injury to the bone marrow, lymph nodes, and spleen producing leukopenia and thrombocytopenia. Other systemic effects include: fever; CNS depression; bradycardia or cardiac irregularities; hemoconcentration; and shock.

Chronic Exposure: HD can cause sensitization, chronic lung impairment, (cough, shortness of breath, chest pain), cancer of the mouth, throat, respiratory tract and skin, and leukemia. HD has also been shown to be mutagenic and carcinogenic in animals. Prolonged human exposure has been associated with cancer of the tongue, paranasal sinus, larynx, bronchus, lung, and mediastinum (cavity between the right and left lung). Tumors observed have been of squamous (scale like) or undifferentiated (altered) cell types. Consider the possibility of skin cancer because of the frequency of this lesion in animal studies. Since sulfur mustard (HQ) agent is similar in its effects to nitrogen mustard, which has been associated with human leukemia, this disease might also be expected to occur in humans chronically exposed to mustard.

Emergency And First Aid Procedures:

Inhalation: Hold breath until respiratory protective mask is donned. Immediately remove from the HD source. Seek medical attention immediately. If breathing is difficult, administer oxygen. If breathing has stopped, give artificial respiration. Mouth-to-mouth resuscitation should be used when approved mask-bag or oxygen delivery systems are not available. Do not use mouth-to-mouth resuscitation when facial contamination is present.

Eye Contact: Speed in decontaminating the eyes is absolutely essential. Remove the person from the liquid source immediately; flush the eyes immediately with sterile saline or water for at least 15 minutes by tilting the head to the side, pulling the eyelids apart with the fingers and pouring water slowly into the eyes. Do not cover eyes with bandages but, if necessary, protect eyes by means of dark or opaque goggles. Transfer the patient to a medical facility.

Skin Contact: Don respiratory protective mask. Remove the victim from agent sources immediately. Seek medical attention immediately. Immediately remove all contaminated clothing in a clean air environment as quickly as possible. Wash contaminated skin area with warm or hot water at least 3 times. Use liquid soap (dispose of container after use and replace), copious amounts of the water and mild to moderate friction with a single-use sponge or washcloth in the first and second wash (do not use a brush, it may enhance absorption into the skin). The third wash should be a rinse with copious amounts of warm or hot water. Shampoo can be used to wash the hair to prevent vapor off gassing.

Ingestion: If ingested, directly or from liquid contaminated food or drink, necrosis, diarrhea, GI hemorrhage, nausea and vomiting will be present. DO NOT induce vomiting. Give victim milk to drink. Seek medical attention immediately.

Section VI - Reactivity Data

Stability: Stable at ambient temperatures. Decomposition temperature is 300-351 ° F (149 -177 ° C). Mustard is a persistent agent depending on pH and moisture, and has been known to remain active for up to three years in soil.

Incompatibility: Rapidly corrosive to brass at 65 ° C. Will corrode steel at a rate of .0001 in. of steel per month at 65 ° C.

Hazardous Decomposition: Mustard will hydrolyze to form HCl and thiodiglycol.

Hazardous Polymerization: Does not occur.

Section VII - Spill, Leak, And Disposal Procedures

Steps To Be Taken In Case Material Is Released Or Spilled: Only personnel in full protective clothing (See Section VIII) will be allowed in an area where HD is spilled. See Section V for emergency and first aid instructions.

Recommended Field Procedures: The HD should be contained using vermiculite, diatomaceous earth, clay or fine sand and neutralized as soon as possible using copious amounts of 5.25% sodium hypochlorite solution. Scoop up all material and place in an approved DOT container. Cover the contents with decontaminating solution as above. The exterior of the container will be decontaminated and labeled according to EPA and DOT regulations. All leaking containers will be over packed with sorbent (e.g. vermiculite) placed between the interior and exterior containers. Decontaminate and label according to EPA and DOT regulations. Dispose of the material in accordance with waste disposal methods provided below. Conduct general area monitoring with an approved monitor to confirm that the atmospheric concentrations do not exceed the airborne exposure limits (See Sections II and VIII).

If 5.25% sodium hypochlorite solution is not available then the following decontaminants may be used instead and are listed in the order of preference: **Calcium Hypochlorite, Decontamination Agent (DS2), and Super Tropical Bleach Slurry (STB).

****Warning:** DO NOT USE PURE SOLID, UNDILUTED CALCIUM HYPOCHLORITE (HTH); it will BURN UPON CONTACT to liquid mustard.

Recommended Laboratory Procedures: Use a minimum of 65 grams of decontamination solution for each gram of HD. Allow 24 hours for decontamination to take place. Agitate solution at least one hour. Agitation is not necessary after the first hour. Test for presence of active chlorine by use of acidic potassium iodide solution to give free iodine color. Adjust the resulting solution pH to between 10 and 11.

Place three milliliters (ml) of decontaminated solution in a test tube. Add several crystals of potassium iodine and swirl to dissolve. Add 3 ml of 50 wt.% sulfuric acid: water and swirl. **Immediate** iodine color shows the presence of active chlorine. If negative, add additional decontaminant to the decontaminated solution, wait two hours and test again for active chlorine. This works for either 5.5% sodium hypochlorite or 10% calcium hypochlorite decontamination solutions. Scoop up all materials and clothing and place in an approved DOT container. The exterior of the container will be decontaminated and labeled according to EPA and DOT regulations. All leaking containers will be over packed with sorbent (e.g. vermiculite) placed between the interior and exterior containers. Decontaminate and label according to EPA and DOT regulations. Dispose of contents according to Federal, state and local regulations. Conduct general area monitoring with an approved monitor to confirm that the atmospheric concentrations do not exceed the airborne exposure limits (See Section VIII).

Note: Surfaces contaminated with HD, then rinsed and decontaminated may evolve sufficient HD vapor to produce a physiological response. HD on laboratory glassware may be oxidized by its vigorous reaction with concentrated nitric acid.

Waste Disposal Method: Open pit burning or burying of HD or items containing or contaminated with HD in any quantity is prohibited. Decontamination of waste or excess material shall be accomplished according to the procedures outlined above and can be destroyed by incineration in EPA approved incinerators according to appropriate provisions of Federal, State and local Resource Conservation Recovery Act (RCRA) regulations.

Note: Some decontaminant solutions are hazardous wastes according to RCRA regulations and must be disposed of according to those regulations.

Section VIII - Special Protection Information

Respiratory Protection:

Concentration
< 0.003 mg/m³

Respiratory Protective Equipment
M40 protective mask and other air
purifying respirator approved by ODAS
for chemical agent operations.

>= 0.003 mg/m³
At an 8-hr TWA

NIOSH/MSHA approved self-contained
breathing apparatus or combination airline
respirator with an auxiliary self-contained
breathing apparatus worn with encapsulating
ensembles other than the DPE.

Ventilation

Local Exhaust: Mandatory. Must be filtered or scrubbed. Air emissions shall meet local, state and federal regulations.

Special: Chemical laboratory hoods will have an average inward face velocity of 100 linear feet per minute (lfpm) +/- 20% with the velocity at any point not deviating from the average face velocity by more than 20%. Existing laboratory hoods will have an inward face velocity of 150 lfpm +/- 20%. Laboratory hoods will be located such that cross drafts do not exceed 20% of the inward face velocity. A visual performance test using smoke producing devices will be performed in assessing the ability of the hood to contain agent HD.

Other: Recirculation of exhaust air from agent areas is prohibited. No connection between agent area and other areas through the ventilation system is permitted. Emergency backup power is necessary. Hoods should be tested semiannually or after modification or maintenance operations. Operations should be performed 20 centimeters inside hoods.

Protective Gloves: Butyl Rubber gloves M3 and M4
Norton, Chemical Protective Glove Set

Eye Protection: As a minimum, chemical goggles will be worn. For splash hazards use goggles and face shield.

Other Protective Equipment: For laboratory operations, wear lab coats, gloves and have mask readily accessible. In addition, daily clean smocks, foot covers, and head covers will be required when handling contaminated lab animals.

Monitoring: Available monitoring equipment for agent HD is the M8/M9 detector paper, blue band tube, M256/M256A1 kits, bubbler, Depot Area Air Monitoring System (DAAMS), Automated Continuous Air Monitoring System (ACAMS), CAM-M1, Hydrogen Flame Photometric Emission Detector (HYFED), the Miniature Chemical Agent Monitor (MINICAM), and Real Time Analytical Platform (RTAP). Real-time, low-level monitors (with alarm) are required for HD operations. In their absence, an Immediately Dangerous to Life and Health (IDLH) atmosphere must be presumed. Laboratory operations conducted in appropriately maintained and alarmed engineering controls require only periodic low-level monitoring.

Section IX - Special Precautions

Precautions To Be Taken In Handling and Storing: When handling agents, the buddy system will be incorporated. No smoking, eating, or drinking in areas containing agents is permitted. Containers should be periodically inspected for leaks, (either visually or using a detector kit). Stringent control over all personnel practices must be exercised. Decontaminating equipment will be conveniently located. Exits must be designed to permit rapid evacuation. Chemical showers, eyewash stations, and personal cleanliness facilities must be provided. Wash hands before meals and shower thoroughly with special attention given to hair, face, neck, and hands using plenty of soap and water before leaving at the end of the workday.

Other Precautions: HD should be stored in containers made of glass for Research, Development, Test and Evaluation (RDTE) quantities or one-ton steel containers for large quantities. Agent containers will be stored in a single containment system with in a laboratory hood or in double containment system.

For additional information see "AR 385-61, The Army Toxic Chemical Agent Safety Program," "DA Pam 385-61, Toxic Chemical Agent Safety Standards," and "DA Pam 40-173, Occupational Health Guidelines for the Evaluation and Control of Occupational Exposure to Mustard Agents H, HD, and HT."

Section X - Transportation Data

Note: Forbidden for transport other than via military (Technical Escort Unit) transport according to 49 CFR 172

Proper Shipping Name: Toxic liquids, n.o.s.

Dot Hazard Class: 6.1, Packing Group I, Hazard Zone B

Dot Label: Poison

Dot Marking: Toxic liquids, n.o.s. Bis- (2-chloroethyl) sulfide UN 2810, Inhalation Hazard

Dot Placard: Poison

Emergency Accident Precautions and Procedures: See Sections IV, VII and VIII.

Precautions To Be Taken In Transportation: Motor vehicles will be placarded regardless of quantity. Drivers will be given full information regarding shipment and conditions in case of an emergency. AR 50-6 deals specifically with the shipment of chemical agents. Shipment of agents will be escorted in accordance with AR 740-32.

The Edgewood Chemical Biological Center (ECBC), Department of the Army believes that the data contained herein are actual and are the results of the tests conducted by ECBC experts. The data are not to be taken as a warranty or representation for which the Department of the Army or ECBC assumes legal responsibility. They are offered solely for consideration. Any use of this data and information contained in this MSDS must be determined by the user to be in accordance with applicable Federal, State, and local laws and regulations.

Addendum A

Additional Information For Thickened HD

Trade Name And Synonyms: Thickened HD, THD

Trade Name and Synonyms for Thickener:

Acrylic acid butyl ester
Polymer with styrene
Butyl acrylate-styrene polymer
Butyl acrylate-styrene copolymer
N-Butyl acrylate-styrene polymer
Polymer with styrene acrylic acid butyl ester
2-Propenoic acid
Butyl ester
Polymer with ethenylbenzene
Styrene -butyl acrylate polymer
Acronal 4D
Acronal 290D
Acronal 295D
Acronal 320D
Mowilith DM60
Sokrate LX 75
OSH22097

Hazardous Ingredients: Styrene-butyl acrylate copolymer is used to thicken HD and is not known to be hazardous except in a finely-divided, powder form.

Physical Data: Essentially the same as HD.

Fire And Explosion Data: Same as HD. Thickener is a slight fire hazard when exposed to heat or flame.

Health Hazard Data: Same as HD except for skin contact. For skin contact, don respiratory protective mask and remove contaminated clothing **Immediately**. **Immediately** scrape the HD from the skin surface, and then wash the contaminated surface with acetone. Seek medical attention **Immediately**.

Spill, Leak, and Disposal Procedures: If spills or leaks of HD occur, follow the same procedures as those for HD, but dissolve THD in acetone before introducing any decontaminating solution. Containment of THD is generally not necessary. Spilled THD can be carefully scraped off the contaminated surface and placed in a fully removable head drum with a high density, polyethylene lining. THD can then be decontaminated, after it has been dissolved in acetone, using the same procedures used for HD. Contaminated surfaces should be treated with acetone, then decontaminated using the same procedures as those used for HD.

Note: Surfaces contaminated with THD and then rinse-decontaminated may evolve sufficient HD vapor to produce a physiological response.

Special Protection Information: Same as HD.

Special Precautions: Same as HD with the following addition. Handling the THD requires careful observation of the "stringers" (elastic, thread like attachments) formed when the agents are transferred or dispensed. These stringers must be broken cleanly before moving the contaminating device or dispensing device to another location, or unwanted contamination of a working surface will result. Avoid contact with strong oxidizers, excessive heat, sparks, or open flame.

Transportation Data: Same as HD